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Signaling the End of Deterrence Afforded by Dual Capable Aircraft

by

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A Research Design Paper Submitted to the Faculty

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6 April 2017

I. INTRODUCTION

For more than 60 years, the United States and Europe relied on fighter aircraft capable of executing conventional and nuclear strike missions. Known as dual-capable aircraft (DCA), these fighters were an integral part of the US extended nuclear deterrence strategy in Asia and Europe. However, the collapse of the Soviet Union in 1991 changed the global security environment. Subsequent political-military decisions regarding force structure, sustainment and modernization by the US and Allied nations allowed tactical nuclear forces to atrophy. Starting in 2010, the US and the North Atlantic Treaty Organization (NATO) sought to redefine the role of non-strategic nuclear weapons (NSNWs) and associated DCA fighters. However, a combination of neglect, fiscal constraint, and public opinion have undermined the deterrent value of these systems.

This paper outlines the historic roots of tactical fighter operations under the extended deterrence strategy in Europe. This paper articulates the current state of US and NATO's tactical nuclear capability and political credibility. Further, it applies each variable to R.J. Overy's equation of deterrence as a function of technical capability and political credibility. Despite NATO posture statements, the analysis reveals that today's tactical nuclear forces lack the technical and political credibility to be an effective deterrent.

II. HISTORICAL UNDERPINNINGS

In 1949, B-29 strategic bombers were withdrawn from Europe in response to the Soviet Union's first successful nuclear weapon test. Shortly thereafter, the United States and its European allies sought to counter the quantitatively superior Soviet army and prevent the spread of communist ideology throughout Europe. Unable to match the Soviet conventional force size, the US and Allied nations adopted an asymmetric counter.¹ Concurrent with the formation of the NATO, the US entered into a series of bilateral agreements that permitted the deployment of

tactical nuclear weapons in certain Allied countries. Dual-capable fighters along with ground-based tactical nuclear assets and strategic forces served to deter the conventional forces from the Soviet Union and Warsaw Pact from invading Western Europe. Known as extended deterrence, the implicit strategy of the US was to raise the cost of a conflict to an adversary to exceed any potential benefit.

The efficacy of extended deterrence is the subject of debate among deterrence theorists. As Bernard Brodie highlighted in his 1959 book, *Strategy In The Missile Age*, the concept of credibility is key to deterrence in the nuclear age. He asserts that there is “little to no problem of credibility” if the US is subject to direct strategic nuclear attack.² However, credibility suffers when attempting to extend deterrence beyond direct attacks against the state itself. Former French President Charles de Gaulle appeared to share Brodie’s concern and pursued the creation of France’s independent deterrent force. Between 1958 and 1966, de Gaulle removed all French forces from NATO’s integrated military command structure. French conventional forces were reintegrated in 2009, but French nuclear forces remain outside the purview of NATO.

Unlike Brodie, Thomas Schelling viewed extended deterrence as a way to keep an adversary guessing about a state’s response to various actions, “...the uncertain element of what might happen in response to a Soviet attack would make extended nuclear deterrence work.”³ Schelling advocated for the deployment of conventional and nuclear forces with the capability to gradually escalate from conventional to nuclear warfare. Schelling focused on fielding a minimum deterrent force that would hold adversary cities and industry at risk (counter-value targeting). Part of the force’s credibility relied on concealing the exact composition and location of these forces. Herman Khan diverged from Schelling’s minimum deterrent, counter-value force, advocating for US strategic forces to possess an array of offensive and defensive

capabilities to limit damage to the US using an imbalance of terror argument. Khan favored Soviet political and military targets (counter-force) in lieu of counter-value targets. Khan's approach follows his assertion that "...the most convincing way to look willing is to be willing."⁴ However, with regard to extended deterrence, Khan believed that threats to initiate nuclear conflict on behalf of an ally were not credible unless the US could limit Soviet retaliatory response against strategic targets in the continental United States.

Ultimately, the US extended deterrence strategy in Europe during the Cold War appears to embody a conflation of Schelling's and Khan's theories. Refusing to acknowledge specific details, the US and certain NATO partners developed and deployed a tactical nuclear force of consisting of more than 1,000 fighter aircraft and 7,300 tactical warheads.⁵ Since then, the number of assigned/available DCA fighters and tactical nuclear weapons (B61) have declined significantly. According to his 2015 article, "US Nuclear Forces, 2015," Hans Christensen of the Federation of American Scientists estimates that there are 180 NSNWs deployed across five NATO bases in Europe.⁶ Compiled from multiple sources, Table 1 depicts the estimated rollout of NATO DCA fighters currently deployed in Europe.

Table 1 -Fighter DCA Inventory by Country		
Country	#/Type of Aircraft Available	# of Aircraft Dedicated
United States	55 F-15Es 51 F-16s	Unknown, see Note 1
Belgium ⁷	54 F-16s	12
Italy ⁸	59 PA-200s (Tornado)	unknown
Netherlands ⁹	61 F-16s	16
Germany ¹⁰	65 PA-200s	44
Turkey ¹¹	~250 F-16s	None certified
Note 1: It is unlikely that all USAF fighter aircraft in Europe maintain a nuclear role based on USAF Chief of Staff, General Mark Welsh, Congressional testimony in 2014 that indicated the USAF had the capacity to increase the operational load. ¹²		

Not only has the size of DCA force decreased, so has its readiness. Previously, a small number of DCA maintained a 5-minute alert posture with additional aircraft ready within hours to days.¹³ A 2004 NATO issue paper disclosed that numbers and readiness levels for DCA had reduced from minutes to weeks in 1995 and further reduced from weeks to months in 2002.¹⁴ Despite the dramatic reduction in the size and readiness NATO's tactical nuclear forces, the Alliance advertises steadfast commitment to the role of NSNWs and by extension, fighter DCA, as having "... [an] essential role in the Alliance's overall strategy."¹⁵

Yet, global and regional security structures have changed. Within Europe, the deployment of advanced surface-to-air missile (SAM) systems threatens to disrupt air operations throughout Central and Eastern Europe. The advanced SAM threat coupled with passive detection systems has the potential to make certain regions around Europe an anti-access and area denial (A2/AD) environment. Meanwhile, the survivability and readiness of NATO tactical nuclear forces has significantly declined. Given this contemporary reality, is fighter DCA still a credible deterrent?

In his article, "Air Power and the Origins of Deterrence Theory before 1939," R.J. Overy defined deterrence as a function of technical credibility (capability) and political credibility.¹⁶ Prior to 1939, airpower theorists postulated that great-power wars could be won by aerial attack by inflicting unacceptable losses against an adversary's population. Overy largely rejects that pre-WWII aircraft had the technical credibility, let alone the political credibility to produce a deterrent effect that would have contained Nazi Germany. However, the advent of nuclear weapons and development of strategic bombers satisfied technical credibility. Although Overy's definition of deterrence may be overly simplified for nuclear deterrence, it provides a mechanism

to evaluate the deterrent value of NATO's tactical nuclear force in the 21st century security environment.

III. CAPABILITY

Per Overy's definition, technical credibility is a function of the weapon and delivery platform pairing. The weapon must function reliably to produce the intended damage. The delivery platform (aircraft), must also have the capability to accurately and reliably deliver the weapon. Therefore, when reviewing nuclear capability, it is important to examine each system independently.

Since 1999, the B61 is the only NSNW type remaining in Europe.¹⁷ Earmarked for tactical delivery by NATO fighters, the US maintains control of these weapons and is responsible for sustainment and modernization of the system. While the B61 is a proven design, the current version of the B61 is more than 30 years old. Under its "3+2" modernization strategy, the National Nuclear Security Agency (NNSA) in partnership with the Department of Defense (DOD), initiated a \$8.9B B61 Life Extension Program (LEP).¹⁸ Dubbed the B61-12, the new variant of the B61 is intended to replace all previous variants (-3, -4, -7, and -11) as well as the B83.¹⁹ Thus, the B61 will be the only gravity nuclear for strategic and tactical aircraft.

According to the NNSA and the AF, the B61-12 program will combine the warhead designs from previous variants of the B61 while refreshing the weapon's non-nuclear components.²⁰ The updated warhead will mate with a new tail sub-assembly (TAS) provided by the AF. The TAS upgrade will replace the parachute delivery system in favor of an inertial-aided guidance unit. Improved accuracy permits the system to use a smaller warhead to achieve the same effects.

The NNSA and AF have already conducted several test drops of the B61-12 from the F-15E. Further integration with NATO platforms was scheduled to start in 2016. While the new B61-12 displays many of the same physical characteristics of the previous variants, it is unclear what aircraft integration modifications (if any) will be required. Modifications to the aircraft's multiplex (MUX) bus or changes to the operational flight program (OFP) will delay the weapon's usefulness until required aircraft modifications are completed and fielded. However, it is likely that the weapon be as reliable and effective as previous variants. Yet, the ageing tactical delivery systems for the B61 present a different challenge.

The F-15E is the newest DCA fighter. First fielded in 1986, the F-15E replaced the F-111s in Europe as a nuclear capable fighter in the mid-1990s. Since then, the aircraft have been widely deployed throughout Europe and the Middle East. Frequent deployments supporting Operations ENDURING FREEDOM and IRAQI FREEDOM have consumed the originally-planned 8,000 hour service life of the airframe. According to the AF, more than 75% of the entire F-15E fleet have exceeded 6,000 flight hours. One of the older F-15Es have flown more than 10,000 hours. Air Combat Command (ACC) has partnered with Boeing to determine how much longer the airframe service life can be extended. ACC expects to extend the airframe life well beyond the originally planned 8,000 hours. Airframe life is not the only issue for the F-15E.

The F-15Es radar and electronic warfare systems have also reached a terminal phase in their service life. In 2008, the AF initiated a modernization program update the F-15E radar. According to the AF, the upgrade was required because the original radar (APG-70) was no longer sustainable. The new radar, APG-82, started fielding in 2014. However, the European-based F-15Es will not start their upgrade until ~2018.²¹ This programmatic decision undercuts

the priority of the tactical nuclear mission. In addition to the radar, the F-15E's original Tactical Electronic Warfare Suite (TEWS) came has also become unsustainable.

Based on 1970's technology, the TEWS is no longer able to counter current and emerging threats. Additionally, the cost to maintain the TEWS system increased more than 259% in the last 10 years.²² In 2015, the AF (through Boeing) selected BAE Systems to upgrade 413 F-15s (C/D/E variants) with a new electronic warfare system. Dubbed the Eagle Passive Active Warning Survivability System (EPAWSS), ACC estimates the program will cost \$7.6B over its life cycle.²³ Per the Air Force's 2015 President's Budget item justification (PB 2015/PE 0207171F), "EPAWSS will replace the obsolete Tactical Electronic Warfare System (TEWS), which will help the aircraft [F-15C/D/E] survive in high threat environments."²⁴ There is no mention that this important upgrade could support the nuclear in the program justification. According to the 2017 EPAWSS budget item, the EPAWSS production contract will not award until mid-FY2019. Thus, the F-15E will remain vulnerable to the ever increasing threat environment well into the 2020s.

Unlike the radar and electronic warfare systems, the F-15E's electro-optical (EO) and infrared (IR) targeting pod has evolved. In 2001, the AF selected Lockheed Martin's Sniper pod as the winner of the Advanced Targeting Pod (ATP) competition. As the Sniper pod fielded, operations in Iraq and Afghanistan increased the requirement for EO/IR pods. ACC assumed central management of all targeting pods and redistributed them across fighter and bomber units. Fighter units, regardless of assigned mission received their allocation of pods using the following standardized formula: # of primary mission aircraft inventory * .6 + 1 spare.²⁵ That means that there are only 30 targeting pods for RAF Lakenheath's 48 primary mission aircraft. While 30 targeting pods might be enough for day-to-day training operations, the number is insufficient to

meet the simultaneous commitments of a Middle East deployment, European and Africa Command (EUCOM and AFRICOM) combat operations, nuclear readiness, and routine training missions. In July 2015, the 492 Fighter Squadron Commander reported that only 20% of the unit's training sorties could be equipped with targeting pods. The EO/IR targeting pod is considered an essential sensor to precisely designate conventional and nuclear targets.

The pace and prioritization of F-15E resourcing and modernization reflects ACC's apathetic attitude toward tactical nuclear operations. Assuming that the current modernization programs remain on schedule, these systems won't be fully fielded until mid-2020. The F-15E will remain extremely vulnerable to current and future threats for the next decade. Even with extensive support aircraft, it is unlikely that the aircraft could effectively deliver a B61 in a contested environment.

The F-16 is the AF's other DCA fighter assigned to EUCOM. Older than the F-15E, the F-16 entered service in 1978. Since then, multiple Blocks (10/15/20/30/40/50/52) have been built and fielded. Like the F-15E, the F-16 airframe has spent much of its 8,000 hour designed service life supporting operations in Europe and the Middle East. Delays in the F-35 program have forced the F-16 to remain in service. In 2012, the AF announced two life extension programs for the F-16, the Service Life Extension Program (SLEP) and the combat avionics program extension suite (CAPES). The SLEP was designed to extend airframe life up to 12,000 hours. The CAPES program included software and hardware modifications for a new radar, electronic warfare system, and cockpit displays.

In FY15, the AF terminated the \$2B CAPES program in lieu of higher priorities. However, according to the 2015 budget item (PB 2015/PE 0207133F), enhancements and improvements to the aircraft's avionics are planned.²⁶ The AF specifically mentions integration

of the B61-12 in the budget item description and justification. The F-16 SLEP, was also cancelled by budget caps imposed by sequestration.²⁷ The loss of the SLEP and CAPES programs draws into question the sustainability and survivability of the F-16. Like the F-15E, it is unlikely that the F-16 could effectively deliver a B61 in anything other than a permissive environment. Eventually, the USAF F-16s will be replaced with F-35As. However, the F-35 will not have DCA capability until Block 4B fields, around 2025. The USAF is not alone in its challenges with its DCA fighter fleet.

The Netherlands and Belgium still operate F-16s. Having entered service in 1979, these aircraft have been operating for more than 30 years. Although the number of hours each country has logged on their airframes is not available, it can be inferred that these aircraft are in need of replacement. In 2013, the Netherlands officially selected the F-35A to replace its F-16s.²⁸ The Dutch plan to purchase 37 F-35s and decommission all of its F-16s starting in 2020. Assuming the Dutch follow this plan, their DCA capability hinges on F-35A Block 4B fielding. The Belgian government has not finalized its decision on F-35 procurement. Belgium plans to retire its F-16s in 2023. The only dual-capable fighter under consideration is the F-35A. Should the Belgian government opt for a different aircraft, it would be several years before the Belgian AF could resume tactical nuclear operations, if ever.

Italy and Germany still rely on their Panavia Tornado IDS (Interdictor Strike) fighter-bomber for DCA. The Tornado entered service in 1980, with an airframe service life of 4,000 hours. In 1995, a service life extension program doubled the airframe time to 8,000 hours. Since then, the Tornado fleets have undergone several software and hardware modifications. Italy expects that it will be able to operate 58 modernized Tornados until ~2025.²⁹ With its plans to

procure 90 F-35s, it is likely that the Italian AF will maintain its DCA capability with the Tornado fleet until it can be transferred to F-35A (Block 4B).

By contrast, the German government is heavily debating the future of its Tornado fleet and the DCA mission. German Air Force (GAF) Tornado airframes seem to have more life remaining than their US counterparts. In 2011, the first GAF Tornado exceeded 5,000 flight hours.³⁰ It was decommissioned shortly thereafter. Additionally, GAF Tornados have continued modernizing their avionics. The most recent upgrade, Avionics System Software for Tornado in Ada 3 (ASSTA 3), upgraded electronic warfare, communication, and weapon delivery capabilities.³¹ The GAF expects to complete the ASSTA 3 upgrade by 2018. However, the GAF Tornado fleet viability was called into question by a 2015 German Defense Ministry report, which indicated only 29 of 66 Tornados (all variants) are operational.³² Depending on their usage, the GAF Tornado could continue flying well into the 2020s. However, the aircraft is not survivable in the modern A2/AD environment. Germany has not committed to replacing its Tornado fleet. In 2016, the Bundeswehr contracted Airbus Defense and Space (Airbus DS) to define future requirements and refine concepts for a future platform to field in the 2030-2040 timeframe.³³ Depending on future procurement plans, the GAF's participation in the nuclear mission will end with the Tornado's retirement.

The lack of attention by the US and NATO Allies toward tactical nuclear operations is evidenced by modernization and procurement strategies that failed to adequately address the role of DCA in the future security environment. As early as 1999, language in the NATO Strategic Concept supported reductions to NATO's conventional and nuclear forces to a minimum level with graduated readiness. The 1999 Strategic Concept stated that "the fundamental purpose of

the nuclear forces of the Allies is political: to preserve peace and prevent coercion and any kind of war.”³⁴ The next paragraph, dictated the Alliance nuclear force posture:

“The Alliance will therefore maintain adequate nuclear forces in Europe. These forces need to have the necessary characteristics and appropriate flexibility and survivability, to be perceived as a credible and effective element of the Allies’ strategy in preventing war.”³⁵

However, the phrase “adequate nuclear force” is highly subjective and has contributed to the current capability deficiency. Suffering from deferred modernization and procurement, aircraft currently tasked to the DCA mission no longer possess the characteristics to be a credible threat in the modern European security environment. The decline in technical capability has paralleled a similar trend in political credibility.

IV. POLITICAL CREDIBILITY

Political credibility is difficult to objectively measure. By proxy, one can use public discourse, policy statements, defense spending, and procurement strategies to gauge the political willingness of a democratic state to use nuclear weapons. As early as 1991, there seems to have been recognition that NSNWs no longer served a military purpose. The 1999 NATO declaration that nuclear weapons were a political tool allowed policy makers to “rubber stamp” unilateral decisions of nuclear force structure and warhead inventory as meeting the criteria for an effective deterrence posture. Additionally, as NATO countries took advantage of the “peace dividend” following the end of the Cold War, funds were diverted from defense to other government programs. Starting in 1991 many NATO members allowed their defense expenditures to fall below 2% of their GDP.

There was little public debate regarding NSNWs and DCA capabilities in Europe until 2005. In April 2005, the German Freedom Democratic Party petitioned the Bundestag (German parliament) to withdrawal US owned tactical nuclear weapons (TNWs, also known as NSNWs)

from German soil.³⁶ The petition was ultimately rejected by the Board of Foreign Affairs, but it did receive broad political support. The following year, several German political parties criticized a draft 2006 German Defense White Paper that did not change their traditional approach to nuclear policy.³⁷ Like Germany, the Belgian parliament passed a similar resolution in 2005 calling for a debate over Belgium's continuing support for NATO's nuclear policy.³⁸ For the first time in 50 years, the existence, role, and support for tactical nuclear weapons under the extended deterrence strategy was publically debated.

In 2006, Greenpeace International commissioned a public opinion poll of NATO nuclear sharing country populations (Turkey, Belgium, Germany, Great Britain, Italy, and the Netherlands) to gauge their awareness and support for NSNWs based in Europe. The survey revealed that collectively, only 35.5% respondents were aware of US-owned nuclear weapons were likely positioned in their country. Further, 63.6% of the total respondents expressed concern about these weapons (concern varied in intensity by country) with only 24.4% expressing significant support for retaining nuclear weapons in Europe. There was overwhelming support (69.2%) for Europe to be free of nuclear weapons.³⁹

Since 2006, there have been an increasing amount of discussion and initiatives related to withdrawing NSNWs from Europe. The nuclear debate has even expanded into civilian nuclear power. In Italy, the public is so anti-nuclear that the government chose to forego civilian nuclear power.⁴⁰ The German public shares the Italian sentiment, rejecting nuclear weapons and nuclear power production. In 2011, German Prime Minister Angela Merkel announced that all German nuclear power plants would be shut down by 2022.⁴¹

The public nuclear discourse spurred NATO reevaluate its role in the contemporary security environment as well as the role of NSNWs remaining in Europe. Concerned about alliance cohesion, the US advanced a plan based on five principals:⁴²

1. NATO should remain a nuclear alliance
2. As a nuclear alliance, member states should share risk and responsibilities
3. NATO should reduce the role and number of weapons
4. NATO allies should pursue territorial missile defense
5. NATO should cooperate with Russia to increase transparency on non-strategic nuclear weapons in Europe

NATO's 2010 Deterrence and Defense Posture Review (DDPR), captured these principals in an attempt to advance further discussions. But the 2010 DDPR fell short of addressing force structure deficiencies and warhead deployment. The 2012 DDPR emphasized the contribution of nuclear weapons as a "core component" of NATO's overall deterrence capabilities and the "supreme guarantee of security."⁴³ It went on to describe that "...the Alliance's nuclear force posture currently meets the criteria for an effective and deterrence and defence posture," but did not preclude further disarmament.⁴⁴ Critics of the 2012 DDPR argue that it sets the conditions for a status quo arrangement between the US and its European nuclear partners with neither side willing to confront the realities of withdrawing or reinvigorating its nuclear capabilities.

Despite NATO's nuclear paralysis, the US has embarked on a massive recapitalization program for its nuclear forces. After years of domestic dispute, President Obama approved a strategic nuclear modernization program expected to cost \$570B over the next 25 years (see Figure 1).⁴⁵ Nuclear warhead types are being consolidated and modernized, the newest stealth bomber is being built with nuclear capability, procurement for the long range standoff cruise missile (LRSO) to replace the air launched cruise missile (ALCM) has commenced, F-35 nuclear capability under the Block 4B upgrade, and the Navy is preparing plans for the next generation of nuclear submarines. From a strategic perspective, this massive acquisition effort underscores

the US commitment to a safe, secure, effective nuclear arsenal. Further, it demonstrates political will to peer adversaries (e.g. Russia).

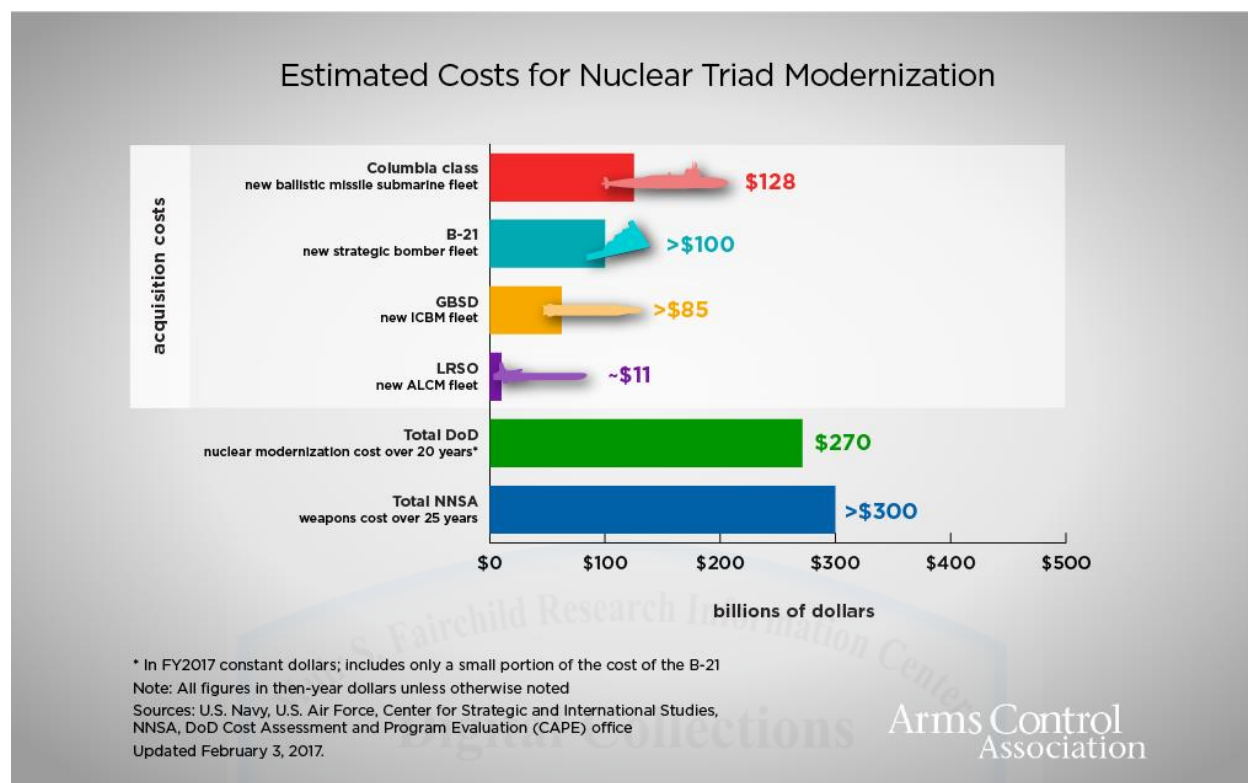


Figure 1 - Estimated Costs for Nuclear Triad Modernization⁴⁶

Allied investment in their nuclear capabilities has been much more reserved. Many Allied leaders still do not confirm or deny the presence of nuclear weapons in their country. In addition, the level of participation their air forces contributes toward nuclear sharing is purposefully obfuscated. Pressure to replace their aging fighter fleets has reopened debate in the public forum because of the nuclear weapon certification requirement tied to future fighter procurement. In 2013, the Belgian government announced it would purchase F-35s to replace their F-16s. However, the government was forced to retract that statement after the decision was subjected to additional scrutiny. According to a 2015 article in *L'Avenir*, the F-35 is the only aircraft in competition that is certified for the nuclear strike mission.⁴⁷ If the nuclear requirement

is retained in government's request for proposal (RFP), the F-35 will be the only option. The Belgian government has deferred its decision to replace their F-16s until 2018.

Italian and Dutch commitment to the F-35 program indicate their willingness to keep the technological door open to the DCA mission. However, specific debate regarding their active participation in the nuclear mission has been mute. Although these governments have not invited public debate, an increasing number of public activist groups and political figures are forcing the issue. In 2013, former Dutch Prime Minister Ruud Lubbers confirmed the presence of B61 bombs on Dutch soil. He considered this previously unacknowledged fact a "...pointless part of military thinking."⁴⁸ In 2016, the Dutch Parliament discussed a national ban on nuclear weapons as a result of a public campaign that garnered broad support across the country. Facing public and political pressure, both governments have been careful to avoid debate on dual-capability for their F-35s. As a result, their respective procurement plans do not cite specific acquisition actions required for add nuclear capability to their fighters. Over-shadowing the nuclear capabilities debate is the issue of cost.

Unlike the US, allied political will is much less resolved. Despite pledges to the contrary, it is unlikely that all NATO members will achieve spending 2% of gross domestic product (GDP) on defense. Even Germany, despite its robust economy, is already seeking ways to redefine how the 2% GDP calculation is made. In a recent CNN article, German Defense Minister Ursula von der Leyen sought to expand the accounting of defense spending to include UN peace keeping missions, European missions and contributions to the fight against ISIS terrorism.⁴⁹ Further, many Western Europeans do not perceive an existential threat that justifies an increase in defense spending. For example, the German populace does not perceive Russia as an existential threat. According to a 2015 Pew survey, only 38% of Germans consider the

Russian military to be a major military threat.⁵⁰ Public opinion, in light of fiscal austerity will complicate future discussions of nuclear burden sharing and contribute to the indecisiveness of NATO, signaling weak political will.

V. TACTICAL NUCLEAR OPERATIONS: NO LONGER A DETERRENT

Per Overy's definition of deterrence, it is clear that the NATO's nuclear sharing partners have significant issues with technical and political credibility underpinning the deterrence value afforded by DCA and NSNWs. While the F-35 may resolve their capability shortfall in 10 years, political credibility will continue to be undermined by public sentiment increasingly in favor of nuclear disarmament. Even the US has demonstrated a lackluster commitment to tactical nuclear operations. With the bulk of US nuclear modernization focused on the traditional strategic triad (bombers, missiles, submarines), tactical nuclear operations will continue to suffer from a lack of resourcing.

Before 1991, tactical nuclear operations were essential to securing Europe from the existential threat posed by the USSR and Warsaw Pact. Neglected for 20 years, the role of nuclear burden sharing reemerged in 2010 as a means of political assurance, not deterrence. The US and its nuclear sharing partners seemed determined to maintain a status quo arrangement out of fear of what might happen if the extended deterrence construct is re-written. The current incarnation of extended deterrence does little prevent adversaries, like Russia, from engaging in coercive against states in its traditional sphere of influence. Although the exact deterrent value of today's tactical nuclear forces varies with the individual psychology of the one being deterred, the Russian annexation of Crimea in 2014 would seem to indicate that the current NATO deterrence construct is insufficient to preserve the European security status quo.

¹ Payne, Keith. *The Great American Gamble: Deterrence Theory and Practice from the Cold War to the Twenty-First Century* (National Institute Press, 2008), p. 21.

² Ibid, 273.

³ Payne, Keith. *The Great American Gamble: Deterrence Theory and Practice from the Cold War to the Twenty-First Century* (National Institute Press, 2008), p 92.

⁴ Ibid, 30.

⁵ Grant, Rebecca, "Victor Alert," *Air Force Magazine*, March 2011 cites that by the late 1970s, the US had 1,000 [fighter] aircraft capable of carrying tactical nuclear weapons. Kristensen, Hans, "US Nuclear Weapons in Europe: A Review of Post-Cold War Policy, Force Levels, and War Planning," documents the total number of nuclear warheads in Europe from 1954-2005. The inventory reached its peak in 1971 with approximately 7,300 deployed warheads.

⁶ Kristensen, Hans, "US nuclear forces, 2015," *Bulletin of the Atomic Scientists, Volume 71, Issue 2.*, 27 November 2015.

⁷ Maitre, Emmanuelle, "Nato, the F35 and European Nuclear Dilemmas," *Notes de la FRS, Number 8/2016*, 22 February 2016, <https://www.frstrategie.org/publications/notes/nato-the-f35-and-european-nuclear-dilemmas-2016-08>

⁸ Ibid.

⁹ Ibid.

¹⁰ Nassauer, Otfried, "Germany's Tornado Nuclear Weapons Carrier," Berlin Information-centers for Transatlantic Security (BITS), January 2013, http://www.bits.de/public/unv_a/original-tornado_eng.htm#fn13

¹¹ Maitre, Emmanuelle, "Nato, the F35 and European Nuclear Dilemmas."

¹² Kristensen, Hans, "US Tactical Nuclear Arms Mission Could Shift Among NATO Jets," 26 March 2014, <http://www.nti.org/gsn/article/aircraft-could-be-given-nato-tactical-nuclear-arms-mission/>

¹³ Grant, Rebecca, "Victor Alert," *Air Force Magazine*, March 2011.

¹⁴ NATO, "NATO's Nuclear Forces in the New Security Environment," NATO Issues, 3 June 2004, <http://nukestrat.com/us/afn/NATOissue060304.pdf>

¹⁵ Kristensen, Hans, "US Nuclear Weapons in Europe: A Review of Post-Cold War Policy, Force Levels, and War Planning," 2005, <http://www.nrdc.org/nuclear/euro/contents.asp>.

¹⁶ Overly, R.J., "Air power and the origins of deterrence theory before 1939," *Journal of Strategic Studies*, Volume 15, Issue 1, 1992, p. 87-92.

¹⁷ NATO, "NATO's Nuclear Forces in the New Security Environment."

¹⁸ US Government Accounting Office, *Nuclear Weapons: NNSA Has a New Approach to Managing the B61-12 Life Extension, but a Constrained Schedule and Other Risks Remain*, February 2016. The report documents the joint NNSA (\$7.3B) and DOD (\$1.6B) estimated program cost of \$8.9B.

¹⁹ Statement of Dr. Donald L. Cook, Deputy Administrator for Defense Programs NNSA, Department of Energy, *B61 Life Extension Program and Future Stockpile Strategy Before the Subcommittee on Strategic Forces House Committee on Armed Services*, 30 October 2013.

²⁰ Ibid.

²¹ The AN/APG-82 program is funded to support two simultaneous modification lines. The first line open at Mountain Home AFB, ID and the second at Seymour Johnson AFB, NC. Once the line at Mountain Home finishes, a new one can be opened at RAF Lakenheath, UK. The modification line at Mountain Home is expected to complete their last aircraft in 2017.

²² Butler, Amy, "Boeing To Select F-15 EW Upgrade Contractor in May," *Aerospace Daily*, 10 March 2015, <http://aviationweek.com/defense/boeing-select-f15-ew-upgrade-contractor-may>

²³ Ibid.

²⁴ US Air Force, *Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Air Force; PE 0207134F / F-15E Squadrons*, March 2014.

²⁵ Allocation based on Air Combat Command internal white paper.

²⁶ US Air Force, *Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Air Force, PE 0207133F / F-16 Squadrons*, March 2014

²⁷ Warwick, Graham "US Air Force Faces Capability Decision On Urgent F-16 AESA Upgrade," *Aerospace Daily*, 30 March 2015, <http://aviationweek.com/defense/us-air-force-faces-capability-decision-urgent-f-16-aesa-upgrade>

²⁸ Dutch Government statement issued 17 September 2013, reprinted by defense-aerospace.com, <http://www.defense-aerospace.com/article-view/release/148024/dutch-government-explainsf-35-decision.html>

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- ²⁹ Defense Industry Daily, “Italy Moves to Complete Tornado Fleet Mid-Life Upgrades,” 10 January 2011, <http://www.defenseindustrydaily.com/Italy-Moves-to-Complete-Tornado-Fleet-Mid-Life-Upgrades-06722/>
- ³⁰ Nassauer, Otfried, “Germany’s Tornado Nuclear Weapons Carrier.”
- ³¹ Ibid.
- ³² BBC News, “Syria conflict: Half of German Tornado jets not airworthy,” 2 December 2015, <http://www.bbc.com/news/world-europe-349833396>
- ³³ Jennings, Gareth, “Airbus DS defining FCAS aircraft requirements with Bundeswehr,” *IHS Jane’s Defense Weekly*, 20 June 2016.
- ³⁴ NATO, *The Alliance’s Strategic Concept*, 24 April 1999.
- ³⁵ Ibid.
- ³⁶ Maetig, Thomas, “Tactical Nuclear Weapons in Germany: Time for Withdrawal?” Nuclear Threat Initiative, 1 March 2008, <http://www.nti.org/analysis/articles/tactical-nuclear-weapons-germany/>
- ³⁷ Maetig, Thomas, “Tactical Nuclear Weapons in Germany: Time for Withdrawal?” Nuclear Threat Initiative, 1 March 2008.
- ³⁸ Ibid.
- ³⁹ *Nuclear Weapons in Europe: Survey Results in Six European Countries*. Study coordinated by Strategic Communications for Greenpeace International, 25 May 2006.
- ⁴⁰ Based on a 2011 referendum that 94% of voters voted to repeal laws allowing operation of nuclear power plants on Italian soil.
- ⁴¹ *Germany: Nuclear power plants to close by 2022*, BBC News, 30 May 2011, <http://www.bbc.com/news/world-europe-13592208>
- ⁴² Pomper, Miles, Sokov, Nikolai, and Meghan Warren, “Delaying Decisions: NATO’s Deterrence and Defense Posture Review,” Nuclear Threat Initiative, 11 May 2012, <http://nti.org/3700A>
- ⁴³ NATO, *Deterrence and Defence Posture Review*, 20 May 2012
- ⁴⁴ NATO, *Deterrence and Defence Posture Review*, 20 May 2012.
- ⁴⁵ *US Nuclear Modernization Programs*, Arms Control Association, February 2017, <https://www.armscontrol.org/factsheets/USNuclearModernization>
- ⁴⁶ Ibid.
- ⁴⁷ *L’Avenir* article published 19 April 2015, reprinted by defense-aerospace.com, <http://www.defense-aerospace.com/articles-view/release/3/162912/no-alternative-to-f-35-if-belgium-keeps-nuke-mission.html>
- ⁴⁸ *US nuclear bombs 'based in Netherlands' - ex-Dutch PM Lubbers*, BBC News, 10 June 2013, <http://www.bbc.com/news/world-europe-22840880>
- ⁴⁹ Euan McKidy, “Germany’s defense minister to Trump: No, we don’t owe NATO money,” *CNN*, 20 March 2017, <http://www.cnn.com/2017/03/politics/nato-commitment-germany-reacts-trump/index.html>.
- ⁵⁰ Pew Research Center, “NATO Publics Blame Russia for Ukrainian Crisis, but Reluctant to Provide Military Aid,” 10 June 2015, 5.

